CONTAMINANT REMOVAL SYSTEM AND METHOD FOR A BODY OF WATER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to systems and methods of water purification, and, more particularly, the control of nutrients, suspended and filamentous algae, pollutants, and toxins in a body of water.

Description of Related Art

Many freshwater lakes and ponds, as well as estuaries, are characterized, particularly during the warmer months, by certain contaminants, such as dissolved color, suspended solids, phosphorus, and heavy metals. Another site of contaminated water is the so-called "waste stabilization pond" (WSP), a body of water used to store industrial, municipal, agricultural wastewater or contaminated groundwater. The WSP is believed to be the most prevalent type of wastewater treatment technology in the world.

Chemical coagulants often are used in water treatment to remove contaminants from the water. In lake water treatment, for example, entire lakes or ponds may be treated with coagulants (typically the aluminum compound "alum"). These are added at or above a "critical" concentration, dictated by water chemical characteristics such as water pH and alkalinity, so that a floc forms. Contaminants in the water column are then encapsulated by, or adsorbed to, the floc, which then settles to the bottom of the lake.

It is also known in the art to treat wastewater with conventional "concrete and steel" chemical technologies, using separate chambers for: (1) adding and mixing coagulant; (2)

rapid mixing to form flocs; and (3) clarifying to permit settling of flocs, subsequently allowing a clear supernatant to flow out from a port near the top of the vessel.

Alternatively, it is known to inject a coagulant into a water inflow pipe just prior to feeding the water into a lake. This may be accomplished, for example, using a flow proportional injection of coagulant into a stormwater inlet pipe, or by injecting the coagulant into a pipe as it feeds into a wetland. In these cases, the floc accumulates in the lake or wetland over time. In yet another method, prior to entering the lake the floc is fed into a clarification or separation vessel, where the floc is captured and disposed of in a sanitary sewer or is used for land application.

For the above-mentioned "concrete and steel" systems, the goal is to achieve a certain pollutant outflow concentration. For the chemical treatment of stormwater feeding into a lake or wetland, the goal is typically focused on mass (or percentage) removal of contaminants. In all cases, however, there is a clear incentive to minimize chemical dose to minimize cost. In cases in which the floc is captured, another goal is to maximize the settling rate of the floc, which minimizes the "carry-over" of floc from the clarifier, since effective floc settling reduces the required size of the clarifier.

SUMMARY OF THE INVENTION

The present invention is directed to a method and system for removing pollutants, such as heavy metals, phosphorus, and pathogenic organisms, from water. The method for treating water comprises the step of adding a chemical coagulant to water containing a pollutant, the water being within an enclosure. The water and the coagulant are mixed, and coagulation and flocculation are permitted to occur. The mixing is stopped, and a floc

formed by the coagulation and flocculation is permitted to settle to a bottom of the enclosure. The floc contains the pollutant, so that treated water remaining above the floc is thereby free from at least some of the pollutant.

At least some of the treated water is removed from the enclosure, and new water containing a pollutant is added to the enclosure. The new water and the floc are then mixed to resuspend components of the floc.

The present technique provides for more efficient use of chemical coagulants, capitalizing on the fact that coagulation and floc formation are dependent on the chemical characteristics of water (e.g., alkalinity, pH) that are not necessarily related to the concentration of contaminants (e.g., phosphorus, heavy metals) desired to be removed from the water.

BRIEF DESCRIPTION OF THE DRAWING

FIGS. 1A-1D is a side cross-sectional view of a vessel system of the present invention, with the method steps illustrated as (FIG. 1A) pumping water into the vessel; adding a coagulant, mixing, and permitting a floc to form (FIG. 1B); halting the mixing and permitting the floc to settle (FIG. 1C); and pumping the treated water out of the vessel (FIG. 1D).

FIG. 2 is a side cross-sectional view of an enclosure system of the present invention contained within a body of water.

FIG. 3 is a side cross-sectional view of a second embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A description of preferred embodiments of the present invention will now be presented with reference to FIGS. 1A-3.

A first embodiment of the method of the present invention, using the systems **10,20** of FIGS. 1A-2, respectively, comprises the steps, illustrated in FIGS. 1A-1D, of feeding water to be treated, which may contain such contaminants as suspended solids, phosphorus, heavy metals, and pathogenic organisms, into an enclosure, which can be a free-standing tank **11** that holds the water to be treated **12** or an enclosure **21** that compartmentalizes a discrete water column **22** within a body of water **23** such as a lake. The feeding step (FIGS. 1A and 2) is typically performed by a pump **13,24**, although this is not intended as a limitation, as a gravity-fed system may also be envisioned by one of skill in the art. The pump may be positioned within the enclosure **21** (pump **24** in FIG. 2) or outside the enclosure **11** (pump **13** in FIGS. 1A-1D).

Next a chemical coagulant, such as an aluminum or iron compound (with chemical pH buffers or coagulant aids, as needed), is added to the enclosure **11,21**. The fluid in the enclosure is mixed using a mixing means **14,25**, allowing coagulation and flocculation to occur (FIG. 1B). The mixing is stopped, and the floc **15** is allowed to settle to the bottom **16** of the enclosure **11**, resulting in the removal of various pollutants from the water, which now reside in the floc **15** in the bottom of the enclosure **11**.

Once the floc **15** is settled (FIG. 1C), the treated water column **12'** above the floc layer **15** is removed (FIG. 1D) and replaced with a fresh aliquot **12"** of contaminated water. This exchange may occur either quickly or slowly, and in a batch or continuous-flow basis.

The floc **15** is left in place on the bottom **16** of the enclosure **11** during the exchange. Once the water exchange has been completed, the floc **15** is resuspended throughout the "fresh" water column **12"** by mixing the water in the enclosure **11**.

Depending on the original concentration of the coagulant added, as well as the concentration of contaminants of the water, it is now likely that the resuspended floc **15** has additional capability to remove contaminants. The mixing is then stopped, and the new floc is allowed to settle to the bottom **16** of the enclosure **11**. This process, including water exchange, resuspension of floc, and settling of floc, is repeated for several iterations, for as long as the floc continues to exhibit contaminant removal capability.

The floc ultimately is removed from the enclosure when its contaminant-removal capacity is exhausted, such as by pumping. In the case of enclosure **11**, the vessel contains a sump **17** positioned adjacent the vessel's bottom **16** from which settled floc may be pumped at predetermined intervals.

Enclosure **31** in another embodiment of the system **30** (FIG. 3) may comprise, for example, a flexible barrier having sides but no bottom. The bottom **32** here is thus the bottom of the body of water **33**. The barrier **31** may be movable, in which case the process is carried out for a predetermined time with the barrier **31** at a first position **34**. Following the predetermined time, the barrier **31** is moved to a second position **35** within the body of water **33** spaced apart from the first position **34**, leaving the settled floc **38** at the first position **34** on the bottom **32**.

In order to provide additional surface area, a matrix element may be added to the enclosure. The matrix element serves to provide a surface onto which floc can settle, this

settled floc then providing additional floc-containing surface area in position to contact water to be treated.

In the embodiment **20** of FIG. 2, the matrix element **26** comprises a plastic "trickling filter media" or baffle such as are known in the art. In the embodiment **30** of FIG. 3, the matrix element comprises a root mat **36** of floating vegetation **37**, which can, for example, be pre-inoculated with floc.

In the embodiment **30** of FIG. 3, if the body of water **33** has a natural (e.g., soil, sand) bottom **32**, the body of water **33** may be periodically drained, and the vegetation **37**, floc associated with the root mat **36**, and settled floc **38** on the bottom **32** tilled into the natural bottom **32**.

In all cases, the overall process is re-started by adding coagulant dose (similar to the original dose) to a fresh parcel of water, thereby forming a "new" aliquot of floc.

Under certain circumstances, the contaminant removal performance of the resuspended floc can be enhanced by adding a small dose of pH buffer, coagulant aid (e.g., a polymer), and/or coagulant (typically at a much lower concentration than the original dose), upon resuspension of the floc in the enclosure.

The method may be performed "manually" or under electronic control, wherein the pumping and mixing elements are under timer control and are coordinated to perform the method steps automatically.

One of the benefits of this invention is that by harnessing the "additional" contaminant removal capability of a previously formed and settled floc through its subsequent resuspension, the mass of pollutant removed per unit mass of coagulant

added can be maximized. This represents a cost savings (reduction in operating costs for coagulant purchase), and in many circumstances, an environmental benefit (reduction of coagulant/floc that ultimately is discharged to the environment).

Another benefit of the current systems and methods is that only one enclosure is required, since it is not critical to achieve a predetermined target outflow concentration.

One of skill in the art will recognize that each body of water and its components will have its own characteristics. Therefore, each site will be evaluated to determine individual design and operational variables, including, but not intended to be limited to, type and dose of coagulant, buffers and coagulant aids; frequency of water exchange; frequency of floc resuspension; dose of additional coagulant, buffer and coagulant aids, at the time of floc resuspension; and method of removing floc.